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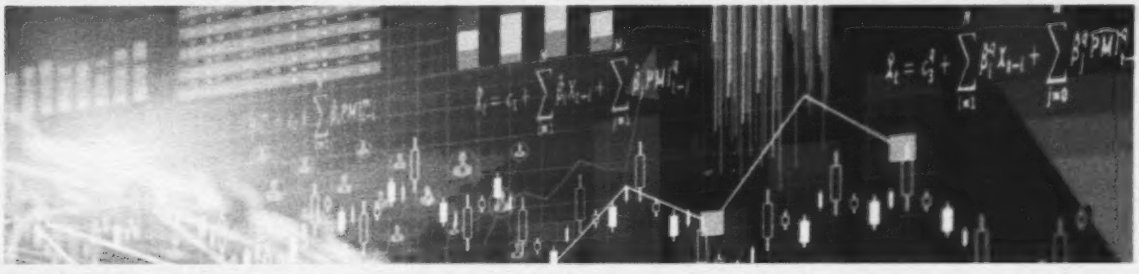

by Itay Goldstein, Jonathan Witmer and Jing Yang

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Following the Money: Evidence for the Portfolio Balance Channel of Quantitative Easing

by

Itay Goldstein,[1] Jonathan Witmer[2] and Jing Yang[3]

[1] Department of Finance
Wharton School, University of Pennsylvania
Philadelphia, Pennsylvania, USA 19104
itayg@wharton.upenn.edu

[2] Financial Markets Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
jwitmer@bankofcanada.ca

[3] Canadian Economic Analysis Department
Bank of Canada
Ottawa, Ontario, Canada K1A 0G9
jyang@bankofcanada.ca

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Abstract

Recent research suggests that quantitative easing (QE) may affect a broad range of asset prices through a portfolio balance channel. Using novel security-level holding data of individual US mutual funds, we establish evidence that portfolio rebalancing occurred both within and across funds. Contrary to conventional wisdom, portfolio rebalancing by fund managers into riskier assets is much smaller in magnitude than into other government bonds. We find that mutual funds replaced QE securities with other government bonds that have similar characteristics. Intriguingly, this shift occurred mainly into *newly issued* government bonds. Such within-fund portfolio rebalancing is material. For every $100 in QE bonds sold, mutual funds replenished their portfolios with about $50 to $60 of newly issued government bonds. Thus, QE played an important role in funding treasury debt issuance during this period. Meanwhile, the rebalancing into riskier assets, such as corporate bonds, did occur, but was mainly carried out by the end investors of the funds instead of the fund managers themselves.

Bank topics: Monetary policy; Monetary policy implementation; Transmission of monetary policy
JEL codes: E5, E58, G23

Résumé

Les études récentes donnent à penser que l'assouplissement quantitatif pourrait influer sur les prix d'un vaste éventail d'actifs par la voie du rééquilibrage des portefeuilles. De nouvelles données sur les titres détenus par divers fonds communs de placement aux États-Unis nous permettent d'établir qu'il y a eu un rééquilibrage des portefeuilles tant au sein des fonds qu'entre eux. Contrairement à ce qu'on pourrait croire, les gestionnaires de fonds ont beaucoup plus tendance à rééquilibrer leurs portefeuilles par d'autres obligations d'État que par des actifs plus risqués. En effet, nous constatons que les fonds communs de placement ont remplacé les titres vendus dans le cadre du programme d'assouplissement quantitatif par d'autres obligations d'État dotées de caractéristiques semblables. Curieusement, il s'agissait surtout de *nouvelles émissions* d'obligations d'État. Ce genre de rééquilibrage des portefeuilles au sein des fonds est important. Pour chaque tranche de 100 $ d'obligations vendue dans le cadre du programme, les fonds communs de placement ont regarni leurs portefeuilles en achetant les obligations d'État nouvellement émises d'une valeur de 50 $ à 60 $. L'assouplissement quantitatif a donc joué un rôle important dans le financement de l'émission de titres du Trésor pendant cette période. Le rééquilibrage par des actifs plus risqués, comme les obligations de sociétés, a quant à lui été observé, mais principalement chez les investisseurs finaux des fonds, plutôt que chez les gestionnaires de fonds eux-mêmes.

Sujets : Politique monétaire; Mise en œuvre de la politique monétaire; Transmission de la politique monétaire
Codes JEL : E5, E58, G23

Non-Technical Summary

Recent research suggests that quantitative easing (QE) may affect a broad range of asset prices. Since investors must purchase securities to replace those QE securities they sell to the central bank, this should influence the prices of these other securities through a so-called portfolio balance channel. Thus, many people attribute the price effect of QE to this portfolio balance channel. However, despite a lot of work examining the price effects of QE, less is known about the effect of QE on investor portfolios.

To understand this channel better, we use security-level holding data of nearly all individual US bond mutual funds, and map these data to individual security QE purchases by the Federal Reserve. Thus, we can determine both i) whether funds reduced their holdings of QE securities in the same quarter that the Federal Reserve was purchasing them, and ii) what they replaced these securities with.

We establish strong evidence that portfolio rebalancing occurred both within funds and across funds around Federal Reserve QE purchases. We find that mutual funds replaced QE securities with other government bonds that have similar characteristics; intriguingly, the shift was mainly into newly issued government bonds. Such within-fund portfolio rebalancing is material. For every $100 in QE bonds sold, mutual funds replenished their portfolios with about $50 to $60 of newly issued government bonds. In comparison, portfolio rebalancing by fund managers into riskier assets was much smaller in magnitude.

Instead, the portfolio rebalancing into riskier assets, such as corporate bonds, did occur, but mainly through the end investors. We find a significant shift into corporate bond funds initiated by the end investors of mutual funds instead of fund managers. Such an across-fund portfolio shift is sizable. Corporate bond funds received an additional 3% of assets in inflows in each QE quarter, relative to government bond funds.

I see the evidence as most favorable to the view that such purchases work primarily through the so-called portfolio balance channel, which ... relies on the presumption that different financial assets are not perfect substitutes in investors' portfolios ... For example, some investors who sold MBS to the Fed may have replaced them in their portfolios with longer-term, high-quality corporate bonds, depressing the yields on those assets as well.

— Ben Bernanke, Jackson Hole, August 27, 2010

1. Introduction and related literature

Quantitative easing (QE), as an unconventional monetary policy tool, was used widely by many central banks in advanced economies since the onset of the financial crisis, including the Federal Reserve, the Bank of England and the European Central Bank (ECB). Policy-makers have consistently emphasized the role of the portfolio balance channel as a key element in the expected transmission of asset purchases to the rest of the economy (see, e.g., Bean 2011 for the Bank of England, Yellen 2011 for the Federal Reserve and Praet 2015 for the ECB). Theoretical models can also demonstrate the portfolio balance channel of QE in the presence of market segmentation and/or capital constraints (see Vayanos and Vila 2009; Gertler and Karadi 2011; He and Krishnamurthy 2013; and Del Negro et al. 2013). According to this channel, by purchasing a large quantity of assets held by the private sector through QE, central banks change the relative supply of the assets being purchased and thus induce changes in their relative yields. Since the base money issued and the financial assets purchased under QE are not perfect substitutes, the sellers of financial assets may attempt to rebalance their portfolios by buying other assets that have similar characteristics to the assets sold. This process, therefore, further pushes up not only the prices of the assets purchased under QE, but also the prices of their close substitutes, and brings down the associated term premiums and yields.

Most of the empirical evidence on the existence of the portfolio balance channel has come from event studies around QE announcements. For example, US QE announcements are associated with a reduction in international bond yields and the US dollar (e.g., Neely 2015), as well as corporate bond yields (Gagnon et al. 2011). ECB QE has had a significant impact on German government yields (Andrade et al. 2016).[1] These announcement effects could be attributable to either the portfolio balance channel or a signalling channel. The former should reduce the term

[1] In contrast, Swedish QE announcements had a negligible impact on local and global term premiums, because these purchases were small compared with a large pool of highly substitutable securities (Diez de los Rios and Shamloo 2017).

premium component of longer-term yields, whereas the latter should reduce expectations of future short-term interest rates. Different studies have offered support for one channel or the other. For example, Bauer and Rudebusch (2014) and Glick and Leduc (2011) both attribute reactions to a signalling of lower future short-term rates. The results often hinge on the asset-pricing model used to decompose yields into risk-premium and expectations components.[2]

We make an important departure from the above existing literature by asking how mutual funds rebalance their portfolios when the Federal Reserve is purchasing Treasuries and Agencies. Federal Reserve asset purchases should push up the price of the assets being purchased, and mutual funds could respond in one of three ways. First, they could maintain their holdings of Treasuries and Agencies, and benefit from the price increase on these holdings. Second, they could sell the assets to the Federal Reserve, and reinvest the proceeds in other, less expensive securities in the same sector (e.g., other government bonds). Third, mutual funds could sell the assets to the Federal Reserve, and reinvest the proceeds in a different sector. The rebalancing behaviour of investors should have implications for how Federal Reserve purchases impact the price of other securities. If funds don't sell to the Federal Reserve, their behaviour should not engender a price increase in other securities. If they sell and reinvest in other sectors, this would suggest that the portfolio rebalance channel reduced borrowing costs more broadly.

Our evidence shows that funds sold to the Federal Reserve are mostly reinvested in other government securities (the second option above). In particular, the proceeds from the sale of QE assets were invested mainly in newly issued government bonds. Such rebalancing by fund managers should help reduce the yields on other government securities, especially the newly issued Treasury securities. This suggests that QE has played a crucial role in funding US government debt issuance throughout this period.

We expect mutual funds, especially those funds with a mixed mandate to invest in both government and corporate bonds, to divert their QE proceeds into riskier corporate bonds. Contrary to this conventional wisdom, however, this rebalancing channel exists but is limited. Instead, we find compelling evidence that the end investors in these mutual funds reinvest their money into

[2] Rebalancing could induce a local supply effect, whereby yields within a particular maturity sector are more sensitive to changes in the outstanding supply in their maturity than to changes in that of other sectors (Krishnamurthy and Vissing-Jorgensen 2011, 2012; D'Amico and King 2013; Joyce et al. 2014). Alternatively, by removing aggregate duration risk from private sector portfolios, central bank purchases can lower the risk premium for holding duration risk (Gagnon et al. 2011).

riskier assets such as corporate and international bond funds in response to QE. Thus, portfolio rebalancing into riskier assets is happening at the fund-investor level rather than the fund-manager level, and suggests that these end investors are helping to propagate the effect of quantitative easing to the prices of other securities.

We study mutual funds instead of banks for two reasons. First, while it is clear that banks played a crucial role in the transmission of QE, other sectors, such as mutual funds and pension funds, also played an essential role as ultimate sellers of the QE assets.[3] To put things in perspective, the Federal Reserve purchased $600 billion in Treasury securities as part of its second QE program alone, much larger than the banking sector's aggregate Treasury holdings of about $100 billion in 2008 (Federal Reserve Flow of Funds).[4] Second, the unique dataset of security-by-security-level holdings of individual mutual funds in the US can provide a detailed account about how money moved around, within and across funds during the QE period. Such level of detail in the holding position is impossible to obtain for major banks. Therefore, we use US mutual funds as a laboratory to study the portfolio rebalance channel of QE.

Our paper contributes to the small literature on the effect of QE purchases on the portfolios of market participants. Joyce, Liu and Tonks (2014) use micro-level data on UK pension funds and insurance companies to investigate the portfolio balance effect around UK QE announcement dates. Carpenter et al. (2013) use US Federal Reserve Flow of Funds data to investigate how different sectors responded to Federal Reserve asset purchases. Unlike these studies, our study can identify the mutual funds that hold the specific securities purchased by the Federal Reserve each quarter, which enables us to better identify the effects of QE on fund portfolio decisions.

Koijen et al. (2016, 2017) and Albertazzi, Becker and Boucinha (2016) use security-level portfolio holdings by investor type and across countries in the euro area to investigate the participation of ECB's QE program. They find that, in Europe, foreign investors and banks were the most important participants in selling assets to the ECB during its asset purchase program (Koijen et al. 2017). Albertazzi, Becker and Boucinha (2016) use the same dataset and focus on how the ECB's QE program affects country/sector-level holdings of assets. Quantifying a sector's

[3] For example, Kandrac and Schlusche (2016), Christensen and Krogstrup (2016a, 2016b), Chakraborty, Goldstein and MacKinlay (2016) and Daetz et al. (2016) all investigate the impact of QE through the banking channel.
[4] Mutual funds, in contrast, held almost twice the amount of banks.

exposure to QE by measuring the return of each sector's portfolio around the announcement of the ECB's asset purchase program, they find some rebalancing towards corporate bonds in some more vulnerable economies.

We differ from these studies along several dimensions. First, we focus on the US QE programs, rather than the ECB and Bank of England programs. One salient feature is that the issuance of government bonds increased much more in the US throughout the Federal Reserve QE period while the governments in the euro area economies were undergoing a fiscal austerity when the ECB carried out its asset purchase program. The fact that we can differentiate newly issued government bonds from existing ones helps us to pinpoint the crucial channel through which QE purchases have been transmitted. We find that for each $100 that a mutual fund received by selling QE assets to the Fed, they used $50–60 to replenish their portfolio with newly issued government bonds. In other words, by selling assets to the Fed, financial intermediaries made room to absorb newly issued government bonds. In this sense, the QE helped the US treasury to finance the new government debt issuance, which was proven essential at the time of crisis. Second, we show how rebalancing occurs at the fund-manager and fund-investor level, underscoring how frictions and mandate constraints impact the transmission of the portfolio rebalance channel. Portfolio rebalancing into riskier assets was stronger in fund managers with more flexible mandates. In a difference-in-difference analysis, we find that, in QE quarters, investors reduce their exposure to funds focused on government securities and increase their exposure to corporate bond funds.

2. Data and methodology

To understand mutual fund portfolio balancing behaviour in response to Federal Reserve asset purchases, we combine two securities-level datasets. The first contains information at a quarterly frequency of the individual securities holdings of bond mutual funds. The second dataset identifies Federal Reserve asset purchases of individual securities from changes in the quarterly holdings of the Federal Reserve's System Open Market Account (SOMA) portfolio holdings. From the interaction of these two data sources, we can analyze how mutual funds' holding of securities that the Fed is purchasing affects the mutual fund's portfolio decisions.

2.1 Mutual fund portfolios

We extract information on the quarterly securities holdings of mutual funds from Morningstar. Our sample period begins in 2006 Q1, prior to QE by the Federal Reserve, and ends in 2014 Q3, just as the Federal Reserve was finishing its tapering of its QE. Our study is concerned with bond mutual funds, which we define as any fund that holds at least 70% of its (non-derivative) securities classified as bonds by Morningstar. We also exclude Municipal bond funds: those that hold more than 90% of their portfolio in Municipal securities or have a Municipal index as their benchmark. After these filters, our sample contains 896 bond funds. We focus exclusively on the bond holdings of these bond funds.

From **Table 1, Panel A**, there is a wide variety in fund mandates, which will influence the extent to which funds undertake QE-related portfolio rebalancing. We base our classification of fund mandates on the benchmark indexes of the funds in our sample.[5] On the one hand, "pure" funds appear to have more narrow objectives and may be considered as preferred habitat investors and less likely to participate in QE portfolio rebalancing. We find 170 funds in the sample are "pure" government funds, benchmarking against a US government index. The "pure" government funds are unlikely to buy bonds outside their mandates. There are 192 corporate bond funds, which have a mandate to focus on corporate bonds, and 65 international funds whose mandate is to focus on international bonds. The corporate and international funds hold, on average, less than 5% of their portfolios in government securities, so they do not have many assets to sell to the Federal Reserve.

On the other hand, there are several "mixed" funds that not only hold government securities that the Fed aims to buy, but also have the mandate to invest in other asset classes. Therefore, we are most likely to observe portfolio rebalancing in these funds if it exists. These may be considered arbitrageurs in the Vayanos and Vila (2009) setting. There are 460 "mixed" funds that have a broad benchmark index. These funds, on average, invest about 25% of their portfolios in corporate bonds, about 30% in government and Agency securities and about 15% in international bonds. For each of these bond funds, Morningstar provides securities-level data on the holdings of the bond. This

[5] A small number of funds do not report a benchmark index. For these funds, we classify them based on their average portfolio allocations over the sample period. For example, funds with average allocations greater than 95% to government and Agency securities would be classified as "pure" government.

includes the bond's name and Committee on Uniform Security Identification Procedures (CUSIP) identifier, the market value of the bond, the par value of the bond, the bond's coupon rate and the bond's maturity.

Following other research, we back out mutual fund flows using the change in the total net assets of fund j (TNA) at time t, as well as its return (see, e.g., Coval and Stafford 2007). This assumes that the flow is equal to the percentage change in the fund's assets under management, less the fund's return:

$$Flow_{j,t} = \frac{TNAj,t}{TNA_{j,t-1}} - (1 + Return_{j,t}) \quad (1)$$

We calculate the fund return using the appreciation of the fund's individual bonds i, weighted by the size of each bond's market value (MV) in the fund's overall portfolio:

$$Return_{jt} = \frac{\sum_i MV_{i,j,t-1} * \frac{PRICEi,j,t}{PRICEi,j,t-1}}{TNA_{j,t-1}} - 1 \quad (2)$$

We are interested in how allocations to different sectors change due to QE. The change in the dollar allocation to an individual bond (which can then be aggregated to the sector level) can be calculated from the bond's par value and price. Essentially, we are measuring the change in the holdings of the bond, and not measuring changes in sector allocations due to valuation changes since we are holding the price was constant at its current level:

$$\Delta Allocation_{i,j,t,} = (\text{Par Value}_{i,j,t} - \text{Par Value}_{i,j,t-1}) * \text{Price}_{i,j,t} \quad (3)$$

Flows must result in a change in allocation to different sectors. It is easy to show that the fund flows defined above can also be expressed as

$$Flow_{j,t} = \frac{\sum_i \Delta Allocation_{i,j,t}}{TNA_{j,t-1}} \quad (4)$$

A fund may change its allocation to a given bond or sector if it receives inflows or outflows. We assume that a fund will proportionally invest (divest) any inflows (outflows) it receives. The abnormal allocation to a bond is therefore the allocation change beyond what would be expected given the flows the fund received:

$$\%\Delta Abnormal\ Allocation_{i,j,t} = \frac{\Delta Allocation_{i,j,t}}{TNA_{j,t-1}} - Flow_{j,t} * \frac{MV_{j,t-1}}{TNA_{j,t-1}} \quad (5)$$

For a given asset class s (e.g., corporate bonds), the abnormal allocation change is simply the sum of the abnormal allocation change of all bonds within that asset class. For each time period and fund, the sum of these abnormal allocation changes should sum to zero (this can be seen by first summing over equation (5) and substituting in equation (4)).

We also define two other variables at a fund level. The first is $\%SOMA_{j,t}$, which is the proportion of fund j's assets invested in a security at time t that the Federal Reserve has, at some point in our sample period, held in its SOMA portfolio. The second is $\%QE_{j,t}$, which represents the proportion of fund j's assets invested in a security at time t that the Federal Reserve is buying during the quarter between t and $t + 1$.

2.2 Federal Reserve purchases

We obtain the par value of the Federal Reserve's SOMA portfolio individual Treasury and Agency securities holdings at each quarter-end from the Federal Reserve Bank of New York's website. In addition to the amount of each individual Treasury security held in the SOMA account, the Federal Reserve also provides the total outstanding amount of each Treasury security in its portfolio and hence the proportion of the total outstanding that is held in the SOMA account.[6]

Given the large number of Agency securities in its portfolio, the Federal Reserve consolidated similar Agency mortgage-backed securities (MBS) into larger pass-through securities using a CUSIP aggregation service provided by Fannie Mae and Freddie Mac.[7] The Federal Reserve aggregated CUSIPs to reduce operational costs and the complexity of managing a large number of individual Agency MBS CUSIPs. Using the Federal Reserve's mapping list of every Agency MBS CUSIP underlying an aggregated CUSIP, we consolidate securities and perform all of our analyses at the aggregated CUSIP level.

From this information, we can determine whether the Federal Reserve is buying a security as part of its QE programs in a given quarter. The Federal Reserve did not hold any Agency securities in its SOMA account in our sample period before QE1, so if the SOMA holdings of a

[6] Outstanding amounts are not available for Agency securities.
[7] https://www.newyorkfed.org/markets/opolicy/operating_policy_150731.html

SOMA Agency security increase in a given quarter, we classify the Federal Reserve as buying that Agency security as part of its QE program in that quarter.

For Treasury securities, it is not as straightforward to determine whether a security is purchased by the Fed as part of its QE programs for two reasons. First, the Federal Reserve may increase the holdings of an individual security because it is reinvesting the proceeds of its SOMA holdings that are maturing into other securities within its portfolio. For example, in 2006, the Federal Reserve increased its holdings for a large proportion of the Treasury securities in the Federal Reserve SOMA portfolio, well before it implemented its QE program. Second, although the Federal Reserve is purchasing some securities into its SOMA portfolio, it may not necessarily be reducing the net outstanding supply of that security if the US Treasury is issuing more of that security at the same time. To overcome these challenges, we apply two filters in classifying a positive increase in the SOMA portfolio holdings as a QE purchase. First, we require that the Federal Reserve purchase at least 5% of the total outstanding supply of the Treasury security in that quarter. This eliminates the problem of classifying small portfolio changes as QE and also focuses the analysis on purchases that are likely to have a market impact. Second, we also contrast the Federal Reserve purchases with the amount of Treasury issuance in that quarter and require that the Federal Reserve purchases exceed any Treasury issuance of the security. This ensures that the asset purchase is decreasing the public supply of the security.

2.3 The combined dataset

Using each security's CUSIP, we map the Federal Reserve purchases to the Morningstar mutual fund holdings. The resulting dataset contains 328,166 individual securities, the majority of which are Agency securities (**Table 1, Panel B**). The reason for the large number of individual Agency securities in our sample is that the Agency securities are smaller in size: the average aggregate (across all funds) position size is $4.5 million. This contrasts against the 1,360 Treasury securities in the sample, which have an aggregate (again, across all funds) position size of $545 million. Only 7.6% of the individual Agency security CUSIPs held by mutual funds were held in the Federal Reserve's SOMA portfolio at some point in time during our sample period. By contrast, 42% of the individual government bond CUSIPs held by mutual funds were in the Federal Reserve's SOMA portfolio at some point during the sample period.

From **Figure 1**, we can see how mutual fund holdings of Agency and Treasury securities were affected by the Federal Reserve's three QE programs. The Federal Reserve announced its first QE program (QE1) in November 2008. The initial objective of the program was to purchase up to $600 billion in Agency MBS and Agency debt. The program was later expanded in the first quarter of 2009 to purchase an additional $850 billion in Agency debt and Agency MBS as well as $300 billion in Treasury securities. In its transactions, the Federal Reserve made QE purchases (as we have defined them earlier) in about 10% of the individual Treasury CUSIPs and just over 1% of the individual Agency securities held by mutual funds during QE1. This figure is much smaller since the number of Agency securities outstanding from which to purchase (and held by mutual funds) is much larger, and since the QE purchases concentrated on a subset of Agency securities, namely fixed-rate Agency MBS securities guaranteed by Fannie Mae, Freddie Mac and Ginnie Mae.

From the end of 2010 to the middle of 2011, in its second QE program (QE2), the Federal Reserve committed to buying $600 billion of Treasury securities, aiming to acquire about $75 billion each month. Again, given the focus on longer maturity Treasuries, these Treasury purchases represented about 10% of the individual CUSIPs held by mutual funds. Finally, from September 2012 through the end of 2013, the Federal Reserve implemented its third QE program (QE3). After upsizing the program in December 2012, the Federal Open Market Committee authorized $45 billion in monthly Treasury purchases and $40 billion in monthly Agency security purchases. In its Treasury security purchases, this program was smaller than QE2 and focused on a smaller subset of securities, affecting less than 5% of mutual fund CUSIPs. Conversely, QE3 had a larger impact on the number of Agency CUSIPs held by mutual funds. Post QE3, the Federal Reserve continued to reinvest principal from maturing Agency securities in its portfolio into (mostly) newly issued Agency securities.

3. Quantitative easing and mutual fund behaviour

Using mutual fund portfolios, we investigate two prerequisites for the existence of the portfolio balance channel in the transmission of the Federal Reserve's QE. First, when the Federal Reserve purchases assets, some participants need to be selling assets. For the portfolio balance channel to work through mutual funds, these funds should be net sellers of the assets the Fed is purchasing. Second, if funds do sell securities when the Federal Reserve is purchasing them, which

securities do funds rebalance their portfolio towards? If they sell one Treasury bond to the Fed only to buy another Treasury bond with similar characteristics, this would suggest that the portfolio balance channel should have little effect on non-government yields. In contrast, the evidence of the portfolio balance channel would be stronger should they reallocate towards corporate and international bonds. As mentioned before, the funds with narrow investment mandates are constrained by what they can sell and buy. For example, a corporate fund by default does not hold securities that are in the QE program, so they won't be able to sell securities to the Fed. Meanwhile, a pure government bond fund cannot allocate its asset position in corporate bonds. However, it is entirely possible that mutual fund investors can move their money from one type of fund to the other type, for example, from Treasury bond funds to corporate funds, thus playing an important role in QE transmission. Therefore, we also examine the link between fund flows and QE.

3.1 How do mutual fund managers rebalance their portfolios during QE?

If mutual funds sell the Treasuries and Agencies that are being purchased via QE, funds could either increase their cash or increase the allocation to other securities with the sale proceeds. We begin by analyzing portfolio allocations at a fund level, and then look to a security-level analysis to confirm our findings at the fund level. To investigate the portfolio balance behaviour of mutual funds induced by QE, we use both quintile analysis and regressions with fixed effects.

3.1.1 Within-fund allocations by asset class – quintile analysis

The quintile results suggest that funds with more exposure to QE purchases sell more of the securities that the Federal Reserve is buying (**Table 2**). We classify funds based on their exposure to QE purchases. Each quarter, we measure the proportion of the fund's market value that is invested in securities that the Federal Reserve is purchasing. We then divide those funds that have some exposure to QE purchases into quintiles, with funds in the first quintile having the lowest exposure and funds in the fifth quintile having the highest exposure. For all funds (Panel A), funds in quintile 1 have 0.5% of their portfolio exposure to QE purchases, while funds in quintile 5 have about 15% of their portfolio invested in securities the Federal Reserve is purchasing

that quarter.[8] Moreover, since the mixed-mandate funds are better placed to reallocate assets cross different categories compared to more constrained pure-mandate funds, we also perform quintile analyses for mixed and pure funds separately (Panels B and C).

Funds with more exposure to QE purchases sell more of the securities that the Federal Reserve is buying (Panel A, column 6). This can be seen from changes in funds' allocations to QE securities. We measure this allocation change as the dollar change in the fund allocation, as a percentage of the end of the prior quarter's fund assets, less the fund allocation change that could be expected to occur based on fund flows.[9] While there is practically no observable change in fund allocation to QE securities in quintile 1, funds in the highest quintile sell QE securities equal to 2.9% of their assets, on average. This is a substantial amount and represents almost 20% of their holdings of these QE securities. This result is not likely driven by endogeneity since the Federal Reserve was not targeting assets that mutual funds would be more likely to sell.

Our results also suggest that most of the proceeds from selling securities to the Federal Reserve flow to other government securities, representing most of the portfolio balance effect. Quintile 5 funds allocate 2.3% of their portfolio, on average, to non-QE Agency and Treasury securities, which is almost as much as the 2.9% of their portfolio in QE assets that they sold (Panel A, columns 6–7). This is a substantial amount and represents almost 20% of their holdings of these securities.

Rebalancing into corporate bonds also occurs, albeit at a smaller scale (Panel A, Column 8). This full sample result is driven by the action of mixed funds, who have more flexibility to invest across asset classes (Panels B). As expected, such rebalancing is non-existent in pure funds (Panel C). Thus, these summary statistics suggest that mandate constraints may matter for mutual fund portfolio rebalancing. There is no evidence of a shift into international bonds (Column 9).

Federal Reserve purchases occurred at a time when there was a significant amount of Treasury issuance by the US government. Throughout the QE periods, the US government net issuance reached $7 trillion. Even taking into account the total QE purchase of over $3 trillion by the Federal Reserve, such large issuance still results in an increase in net supply of government securities. The more mutual fund managers shift their portfolio into these newly issued government

[8] Part of the reason these funds have a higher exposure is that they focus more on government securities – the lowest quintile has about 15% of its portfolio invested in SOMA, compared with almost half of the portfolio invested in SOMA securities in the highest quintile.

[9] We measure this flow-implied fund allocation by multiplying percentage fund flows by the percentage of the fund's assets invested in the asset class in the prior quarter.

securities, the less effect QE would have on riskier asset classes. In this section, we explore fund allocations into non-QE government securities in greater detail by distinguishing between existing and newly issued government securities.

To this end, we subdivide non-QE government securities into newly issued government bonds and existing bonds. We identify these from mutual fund holdings. A security is considered as "newly issued" when the security first appears in our sample of mutual fund holdings in the current quarter or in the previous quarter.[10] After this, the security is considered an existing bond.

We find that funds allocate a significant portion of their QE proceeds into newly issued government securities (**Figure 2**). As funds have more QE exposure (i.e., moving from quintile 1 to quintile 5), they invest even more in newly issued non-QE government bonds. First-quintile funds allocate a little over 2% of their portfolio towards newly issued, non-QE government securities, while fifth-quintile funds allocate more than 5% of their portfolio.[11] Part of this increase in portfolio allocation is coming from QE securities the funds sell, as fifth-quintile funds sell about 3% of their portfolio worth of QE securities. Meanwhile, allocation out of non-QE previously issued government securities increases from just over 2% in the first quintile to just under 4% in the fifth quintile. Thus, the net proceeds of the QE security sales appear to be going towards newly issued government securities.

3.1.2 Within-fund allocations by asset class – fixed effect regressions

We formally confirm these quintile results using fund-level fixed effect regressions of changes in abnormal portfolio allocations to each asset class.

$$\%\Delta Abnormal\ Allocation_{sjt} = \alpha + \beta_1\ \%SOMA_{jt-1} + \beta_2\ \%QE_{jt-1} + \beta_3\ Flow_{jt-1}$$

[10] We do not have access to good reference data on Agency securities, so we use mutual fund holdings to identify when a security was newly issued. While not a perfect measure, if no single fund in our sample held the security in prior quarters, we take this as a good indication that the security is newly issued.

[11] Regardless of exposure level, funds reallocate from previously issued to newly issued government securities. This rotation is happening for three reasons. First, some of the bonds in the funds' portfolios are maturing and need to be replaced. Second, bond maturities shorten over time, and this shortening may move the bond out of funds' mandates or investment objectives. For example, some funds may not hold a bond until maturity but may sell the bond once its maturity falls below one year, given that bonds are removed from their benchmark indexes once a bond has less than one year to final maturity. Third, newly issued benchmark government bonds are more liquid, and funds may prefer to rotate their portfolio to these newly issued bonds once they become benchmarks.

$$+ \beta_4 Return_{jt-1} + \gamma_j + \epsilon_t + \varepsilon_{jt} \quad (6)$$

where s represents each asset class in portfolios (e.g., QE bonds, non-QE government bonds, corporate bonds and international bonds). *%ΔAbnormal Allocation* to an asset class is defined as the percentage change in allocation beyond what would be expected given the flows its fund received. By construction (apart from some minor differences due to winsorizing), for any given fund j, the sum of the *%ΔAbnormal Allocation* across the different asset classes should equal zero. That is, if a fund allocates more to one asset class, it must allocate less to another (recall that this abnormal allocation measure subtracts off the expected change due to fund flows). Given that this identity holds in the data, it also implies that the coefficients across the different regressions should sum to zero as well (Chang, Dasgupta and Wong 2010).

Our coefficient of interest in the above regression is that associated with *%QE*, the proportion of each fund's portfolio invested in securities that the Federal Reserve was purchasing in the given quarter. *%SOMA* is included as a control to account for the regular portfolio reallocations that may be expected to occur given a fund's holdings of government bonds. This variable measures the proportion of each fund's portfolio invested in bonds that were ever held by the Federal Reserve. If a fund has a higher proportion of its portfolio invested in government bonds in a quarter (relative to its average holdings), it may want to reduce its exposure in the following quarter. We include flows between the previous quarter and the current quarter, since funds may allow inflows and outflows to have a temporary effect on its portfolio allocations. For example, a fund may choose to use more liquid securities, such as government bonds, to minimize liquidity costs associated with investor turnover (e.g., Zeng 2016; Chernenko and Sunderam 2015). Empirical research has shown that fund flows result in an increase in fund investment in liquid assets (Dubofsky 2010). Finally, the fund's lagged return is also included to account for the possibility that bond mutual funds could be positive feedback traders (e.g., Froot, Scharfstein and Stein 1992; Bohn and Tesar 1996).

Mixed funds sell a large portion of their QE securities to the Federal Reserve and, although they allocate most of the proceeds to non-QE government bonds, they invest a small amount into corporate bonds (**Table 3, Panel A**). They reduce their allocation to the securities the Federal Reserve is purchasing in the current quarter by more than 30% given the statistically significant, negative coefficient of -0.313 on *%QE* (column 1). Funds put just under half of the proceeds of the sale into existing non-QE government securities (*%QE* coeff. = 0.135, column 2), and about

half into newly issued government securities (*%QE* coeff. = 0.16, column 3). The quintile analysis showed a larger effect of exposure on rebalancing into newly issued securities since funds that have more exposure to QE also hold more government securities, so they may be expected to rebalance more out of existing securities into newly issued non-QE government securities. The fixed-effects regression analysis controls for this effect by including the *%SOMA* variable.

Mixed funds increase their allocation to corporate securities when they are exposed to more QE purchases, given the positive and significant coefficient on *%QE* in the Abnormal Corporate Allocation regression (column 4). In terms of economic significance, a mixed fund that holds 30% of its portfolio in QE securities would increase its allocation to corporate securities by 0.8% (30% × 0.025). This is similar in magnitude to the quintile results in **Table 2**. Pure funds, as expected, sell fewer QE securities and invest all the proceeds from the sale of QE securities into other non-QE government securities (**Table 3, Panel B**).

3.2 How do investors of mutual funds rebalance their portfolios during QE?

So far, we have analyzed the portfolio rebalancing that occurs inside mutual fund portfolios. It is also possible that the portfolio balance channel could be transmitted through the end investors in mutual funds. Mutual fund investors, for example, could reduce their exposure to Treasury-only funds and increase their exposure to corporate-focused funds by shifting money between different types of funds to achieve higher yields. As such, we would not see this portfolio rebalancing effect in the within-fund analysis as shown in the fund portfolio regressions. These investor fund flows can have real effects on firms. For example, mutual fund redemptions can lead to firm valuation decreases, exposing them to a higher probability of a takeover (Edmans, Goldstein and Jiang 2012). Although we do not have information on the portfolios of individual investors in mutual funds, we can, however, explore how investor flows respond during QE periods.

3.2.1 Investor flows during QE periods - across-fund analysis

To see the flows into different fund types, **Table 4, Panel A** examines whether certain types of pure funds receive more inflows during QE periods than during non-QE periods:

$$Flow_{jt} = \alpha + \beta_1 Flow_{jt-1} + \beta_2 Return_{jt-1} + \beta_3 Family\ Flow_{jt}$$

$$+ \beta_4 QE_t + \beta_5 QE_t * IG\ Corporate\ Fund_j$$

$$+ \beta_6 QE_t * HY\ Corporate\ Fund_j$$

$$+ \beta_7 QE_t * International\ Fund_j + \beta_8 QE_t * Other\ Fund_j$$

$$+ \gamma_t + \epsilon_i + \varepsilon_{it} \qquad (7)$$

In this regression, *QE* is a dummy variable that is equal to one in the quarters when the Federal Reserve was making *QE* purchases (2008Q4–2010Q1; 2010Q4–2011Q2; 2012Q3–2013Q4). Given the inclusion of the interaction terms with the various pure-fund types (*Investment Grade Corporate Fund, High Yield Corporate Fund, International Fund* and *Other Fund*), the coefficient on the *QE* variable represents the change in flows experienced by government funds during QE quarters. The coefficients on the interaction terms represent the change in flows for the other fund types during QE quarters, relative to the change in flows for government funds. We also control for a number of factors. First, we control for flows to fund *j* in the previous period to capture the persistence in fund flows. We also control for past fund returns, as investor flows tend to follow fund performance. Lastly, we include the average fund flows received by other funds within the same fund family, measured by the variable *Family Flow*.

The results in **Table 4** show that non-government funds received more inflows during QE quarters. In column (1), the coefficient on the interaction between *QE* and *HY Corporate Fund* is positive and statistically significant. This conveys that corporate funds received almost 4% of assets more in net flows during QE quarters, relative to the change in flows experienced by government funds. This difference is economically significant given that it suggests a difference of more than 15% of assets in investor flows on an annual basis. The effect is economically stronger for other funds that invest in securities such as asset-backed securities (ABS) and Non-Agency MBS (though weaker statistically). International funds also experience a statistically significant 2% difference in flow behaviour during QE periods.

Our results are not driven by the strong inflows to corporate bonds since 2010. Column (2) includes a *Post-2010* dummy variable that is equal to one in every quarter from 2010 Q1 and after, as well as interactions with the dummy variables representing different types of funds. If inflows after 2010 were indeed the cause, we should witness a significant reduction in the coefficients on the interactions with the QE variable and sizable coefficients on the *Post-2010* interaction

variables. This is not the case. The coefficients on the *QE* interactions are unchanged (albeit with slightly less significance, given the correlation between the *QE* and *Post-2010* variables), and the coefficients on the *Post-2010* interaction terms are mostly insignificant.

The increases in flows into corporate bond funds and international bond funds appear to be at the cost of reduced flow into government bond funds. We exclude time dummy variables in columns (3) and (4) to see the impact that QE has on government funds (in the specifications with time dummy variables, the QE coefficient is swept away by the time dummies). In this specification, the effect of family flows increases, as it replaces some of the impact of the time dummies, which were capturing the average flows across all funds. This suggests that a component of family flows is common across all fund families. The coefficient on the *QE* variable is negative and indicates that government funds received just over 1% less flows in QE quarters than they did in other quarters. This suggests that the combined effect on corporate funds was about 1% more flows than in other quarters (-0.014 + 0.027), which mirrors the change in government flows.

Further supporting our results, investor flows out of government bond funds are higher in those government bond funds that have a higher exposure to QE. Our test is similar to our earlier tests on abnormal allocations (i.e., Equation 6), except that fund flows are the dependent variable. Across all pure funds, the coefficient on *%QE* is a statistically significant -0.128 (**Table 5**). This implies that a fund fully invested in securities the Federal Reserve was purchasing in the same quarter would experience additional outflows of almost 13%. This is above and beyond any effect of holding these securities in the fund's portfolio, given that the coefficient on *%SOMA* is insignificant. Since some of the results may be driven by pure, non-government funds that received inflows and have a near-zero allocation to QE securities, the second column focuses on pure government funds. When examining only pure government funds, the effect is still statistically significant and negative but of a slightly smaller magnitude compared to all pure funds combined. Therefore, some of the flow effect is due to non-government funds receiving inflows when government funds exposed to QE purchases are experiencing outflows.

3.2.2 *Investor flows during QE periods – aggregate flow analysis*

Another way to investigate the investors' behaviour in portfolio rebalancing is to look at fund flows at the aggregate level. The Investment Company Institute (ICI) tracks aggregate net

flows into different fund asset classes at a monthly frequency. To parallel the analysis here, we focus exclusively on bond asset classes (Investment Grade Bond, High Yield Bond, World Bond and Government Bond). These asset classes are slightly different than the ones used in this paper, but nonetheless provide a good measure of whether investors are allocating towards non-government funds.

The ICI measures three types of flows. First, it measures *Total Net Flows* into each of these asset classes. Second, it measures *Internal Net Exchanges*, which captures the portion of *Total Net Flows* that are driven by net flows from other funds within the same fund family. Third, *External Net Flows* are flows from outside the family. To examine flows during QE periods, we run OLS regressions, which include dummies for asset class as independent variables, as well as interactions of these dummies with a dummy variable for QE, which takes the value of one from November 2008 through March 2010, from November 2010 through June 2011, and from September 2012 through October 2014.

During QE periods, investors allocate more flows into high yield bond funds and world bond funds. On a monthly frequency, they allocate 0.5% more into high yield bond funds, and 0.6% more into world bond funds, which implies quarterly flows of 1.5% and 1.8% into these funds (**Table 6**). This is loosely comparable to the quarterly flows into high yield corporate funds (3.7%) and international funds (2.0%) we estimated in the individual fund analysis.

The ICI data are advantageous because it also tracks within-family flows. Presumably, investors face less frictions in transferring funds from one fund to another within the same family. If investors are indeed redeeming from government bond funds and investing in high yield or world bond funds, we should expect to see it in within-family flows. Investors do transfer money from government funds to other funds within the same family, given the negative, statistically significant coefficient on the QE dummy variable in the second column of **Table 6**. High yield bond funds and world bond funds within the same family benefit from the resulting inflows. The pattern in cross-family fund flows is also similar, although it is less statistically significant.

4. Robustness tests

4.1 Effect of Agency MBS vs. Treasury bond purchases

Our results so far suggest that fund managers mostly rebalance within the government asset class. The same is true even when we define the asset class more granularly. Mixed funds sell a

higher proportion of their QE Treasury securities, and practically all the proceeds are redirected into non-QE Treasuries. The abnormal QE Treasury allocation has a -0.428 coefficient on *%QE Treasury*, and the abnormal non-QE Treasury allocation has a 0.431 coefficient on this variable (**Table 7**). Thus, these funds sell upwards of 40% of their Treasury securities that the Federal Reserve is purchasing in the same quarter of the purchase. There is, however, still a small, but slightly larger, amount of portfolio rebalancing into corporate bonds. For Agency securities, only about half of the QE proceeds are reinvested in non-QE Agency securities, with the other half invested in non-QE Treasury securities (coefficients on *%QE Agency* of 0.118 and 0.119, respectively).

Our main results represent permanent portfolio changes. If changes were transitory, we would see the opposite sign on the lags of the *%SOMA Agency*, *%SOMA Treasury*, *%QE Agency* and *%QE Treasury* variables. While there are some small transitory effects, none of them change our main results that the reinvestment of QE proceeds stays mostly within the same asset class. However, a small amount of rebalancing seems to occur with a lag, given that mixed funds increase their allocation towards other securities (e.g., ABS, non-Agency MBS) in the quarter following exposure to Federal Reserve QE Agency purchases, as evidenced by the positive and statistically significant coefficient on the extra lag of *%QE Agency* (0.060).

4.2 Security-level analysis

We confirm our results on sales of QE securities at a security level, reinforcing our confidence in the results on within-fund portfolio rebalancing at a fund level. The fund-level analysis in this paper shows that mutual funds sell the securities that the Federal Reserve was purchasing. As a robustness check, we supplement our analysis by examining whether mutual funds *in the aggregate* sold the individual SOMA securities the Federal Reserve was buying in the same quarter the Federal Reserve was purchasing those securities.

We examine two different dependent variables. The first variable we are interested in is the percentage change in aggregate bond fund holdings of a given security, *%ΔFund Holdings*. Recall that we earlier defined *ΔAllocation* as the dollar change in allocation of a given bond. The aggregate quarterly percentage change is then simply the sum of all these allocation changes across funds, scaled by the market value, *MV*, of that bond held by all funds in the previous period:

$$\%\Delta Fund\ Holdings_{it} = \Sigma_j \Delta Allocation_{ijt} \ / \ \Sigma_j MV_{ijt-1} \qquad (8)$$

The second variable is the percentage change in the number of individual funds that hold the security, *%ΔFunds*. This supplements the analysis to confirm whether the results are due to widespread selling across several funds.

We need to control for the effect of investor flows on the aggregate purchases and sales of securities by mutual funds, as has been done in previous mutual fund research (Coval and Stafford 2007; Manconi, Massa and Yasuda 2012; Ben-Rephael 2014). Following Jotikasthira, Lundblad and Ramadorai (2012), we construct a measure of flow-induced trading of fund allocations to different asset classes. All else being equal, if a security is held by funds that experience a large amount of inflows, we should expect aggregate mutual fund holdings of that security to increase. This "Flow-Implied Fund Allocation," or *FIFA*, measures the change in aggregate fund allocation to an asset class that would be expected as a result of flows from the funds invested in that asset class:

$$FIFA_{it} = \Sigma_j (w_{ijt-1} * flow_{jt}) \quad (9)$$

where fund flows are weighted by w, the share of market value of security i in each fund j relative to the total market value of this security across all funds:

$$w_{ijt-1} = MV_{ijt-1} \; / \; \Sigma_j MV_{ijt-1} \quad (10)$$

To test for the impact of QE on mutual fund holdings, we run a panel regression with both security and time fixed effects. The time fixed effects should control for any market-wide changes in fund allocations to government and Agency securities, while the security fixed effects should account for any unobserved effect influencing allocation changes to each security over the sample period:

$$\%\,\Delta Fund\ Holdings_{it} = \alpha + \beta_1 FIFA_{it} + \beta_2\, QE_{it} + \gamma_t + \epsilon_i + \varepsilon_{it} \quad (11)$$

Our independent variable of interest is a dummy variable, *QE*, which is equal to one in quarters when the Federal Reserve is purchasing that security. If mutual funds do sell securities that the Federal Reserve is purchasing, we should expect a negative coefficient on this variable.

In our regressions results, we do indeed find evidence corroborating our earlier finding that funds are selling assets to the Federal Reserve. For Agency securities, the coefficient on *QE* is equal to -0.22 and is statistically significant, indicating a 22% reduction in fund holdings of Agency securities when they are being purchased by the Federal Reserve (**Table 8**). When the Fed

is buying a given Treasury security, funds decrease their holdings of that specific Treasury security by around 10%. This is roughly in line with the proportion of a security's outstanding amount that the Federal Reserve purchased when it buys Treasury securities (recall that we conditioned on the Federal Reserve purchasing at least 5% of a security's outstanding amount to classify a Fed Treasury purchase as QE). This is consistent with the findings of Koijen et al. (2016), who show that European mutual funds sell like the aggregate investor following the ECB's QE. The results are similar using the percentage change in the number of individual funds that hold the security as the dependent variable.

4.3 Definition of QE Treasury purchases

Our results do not change much if we change our definition of QE Treasury purchases. In our analysis, we apply a threshold to identify Federal Reserve Treasury QE purchases, and this could result in an understatement of the amount of QE purchases. We require that the Federal Reserve purchase at least 5% of the outstanding par value of a Treasury bond in a quarter to be classified as QE. The purpose of this threshold is to focus on effects that are likely to have a measurable impact on mutual fund behaviour. If only, say, 0.5% of a bond is purchased in a quarter, it will result in smaller changes to mutual fund portfolios than a purchase of 10% of the outstanding par value of a bond.

To determine whether our 5% threshold misses an economically significant amount of QE purchases, **Figure 3** plots the aggregate quarterly amount of Treasury QE purchases using different thresholds as well as the quarterly change in the Federal Reserve's SOMA holdings of Treasuries. During QE1, QE2 and the latter part of QE3, using any threshold understates the quarterly change in the SOMA portfolio. This is because we also do not classify a purchase as QE if Treasury issuance exceeds Federal Reserve purchases of a given bond in a quarter. Although we understate QE purchases by $100 billion during some quarters of QE2, the QE purchases we do not consider do not result in a reduction in the net supply of that specific bond (e.g., public holdings outside of the consolidated balance sheet of the Treasury and Federal Reserve), and hence should not result in incentives for mutual funds to sell that bond. Post-QE2, we can see the results of Operation Twist. The net change in the SOMA portfolio is close to zero, yet all the thresholds considered show that the Federal Reserve was purchasing bonds in these quarters. The figure also illustrates

that using a threshold of 5% results in a small understatement of QE purchases relative to the three other thresholds we consider (0%, 1% and 3%).

However, the effect of QE on mutual fund portfolio rebalancing is similar if we identify Treasury QE purchases using a 1% threshold instead of a 5% threshold (**Table 9**). Compared to **Table 3**, the coefficient on *%QE* is -0.279 for the abnormal allocation to SOMA QE bonds in mixed funds using the 1% threshold, relative to -0.313 when using the 5% threshold. Like the earlier results, the same coefficient for SOMA non-QE bonds is of the same magnitude but of the opposite sign, maintaining the result that most of the QE rebalancing went into other government securities.

4.4 Passive vs active funds

Our results on rebalancing into corporate securities are robust to focusing on the more active mixed funds. The reduced allocation to securities the Federal Reserve is purchasing in the current quarter and the increased allocation to non-QE government securities may be the result of passive rebalancing effects (i.e., following changes in the index). QE purchases and Treasury issuance both affect the benchmark indexes against which mutual funds track their performance. A Federal Reserve purchase removes a security from the public float, and this, in turn, reduces the weight of that bond in bond benchmarks. Likewise, Treasury issuance of a security also increases the public float of the security and hence its weight in the benchmark indexes. Because mutual funds do not want to deviate too much from their benchmarks, they have incentives to sell the QE securities the Federal Reserve is purchasing and to buy the government securities the Treasury is issuing.

To see whether our results are present in active funds, we perform our test on a subset of more actively managed mixed funds. We look at both non-index funds as well as funds that have a higher *Active Share* (Cremers and Petajisto 2009), calculated at a quarterly frequency. We focus on only those funds with an *Active Share* greater than 0.6, since Cremers and Petajisto (2009) suggest that equity funds with an *Active Share* below 0.6 are closet indexers. Since only a small fraction of bond funds has an *Active Share* below 0.6, we also consider a higher threshold of 0.9 for evaluating the most active funds. *Active Share* measures how similar a fund's portfolio is to

that of a benchmark and ranges from 0 to 1 with a lower *Active Share* indicating more passive management:[12]

$$Active\ Share_{jt} = \tfrac{1}{2} \Sigma_i |w_{i,j,t} - w_{i,t,index}| \quad (12)$$

Rebalancing into corporate bonds is similar in a subset of more active mixed funds, since the coefficient on $\%QE$ is virtually unchanged across the different subsets of funds (**Table 10**). The coefficient is the same whether we look at all funds (Column 1), non-index funds (Column 2) or those with a higher *Active Share* (Columns 3–4).

5. Concluding remarks

Most research regarding the portfolio balance channel focuses on the behaviour of government bond prices and other asset prices around QE announcements. In this paper, we depart from this literature by analyzing directly how QE alters the quantities of individual securities held by mutual funds.

Our results suggest that Federal Reserve quantitative easing initiated important portfolio balance effects in mutual fund portfolios. Contrary to the common wisdom about the portfolio balance channel, mutual funds use most of the proceeds from QE to purchase other government and Agency securities, rather than corporate bonds. In particular, a large portion of this rebalancing went into newly issued government securities. For every $100 in QE bonds mutual funds sold, mutual funds replenished their portfolios with about $50 to $60 of newly issued government bonds. This implies that, by purchasing existing government debt from financial institutions in the secondary market, QE helped the US Treasury to finance government debt issuance, which also raises a concern on the viabilities of new debt issuance in the future, especially on the exit of the QE.

Although mutual funds shifted only a small portion of their portfolio into riskier assets, the end investors, in contrast, redeemed from government-focused funds and invested in corporate bond funds, suggesting that portfolio rebalancing was undertaken by end investors across different

[12] Since we do not have the holdings of the major bond benchmarks, we use the holdings of the bond index funds that we have in our sample. As do Cremers and Petajisto (2009), we measure *Active Share* against all the potential benchmarks in our sample and take the minimum so that we are calculating *Active Share* relative to a fund's closest benchmark index.

funds, rather than by fund managers within funds. The overall effect of this is quite significant, as corporate bond funds received an additional 3% of assets in inflows in each QE quarter, relative to government bond funds.

Appendix A. Variable descriptions.

FIFA	This variable measures the concurrent weighted average flows of funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio.
SOMA Indicator	This dummy variable takes the value of 1 if the security was ever held in the Federal Reserve's SOMA portfolio during the sample period.
Fed Buying	This dummy variable takes the value of 1 if the security was purchased by the Federal Reserve during the current quarter.
%SOMA	This variable measures the concurrent weighted average portfolio allocation to SOMA securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio.
SOMA Government Exposure	This variable measures the concurrent weighted average portfolio allocation to SOMA Treasury securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio.
SOMA Agency Exposure	This variable measures the concurrent weighted average portfolio allocation to SOMA Agency securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio.
SOMA Short Maturity Exposure	This variable measures the concurrent weighted average portfolio allocation to SOMA short maturity securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio. Short maturity securities are defined as those with a maturity less than 10 years.
SOMA Long Maturity Exposure	This variable measures the concurrent weighted average portfolio allocation to SOMA long maturity securities for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio. Long maturity securities are defined as those with a maturity greater than or equal to 10 years.
%QE	This variable measures the concurrent weighted average portfolio allocation to SOMA securities that the Federal Reserve is buying in the current quarter for all funds that hold the security. Weights are determined based on the market value of the security held in each fund's portfolio. SOMA Government Fed Purchase Exposure, SOMA Agency Fed Purchase Exposure, SOMA Short Maturity Fed Purchase Exposure, and SOMA Long Maturity Fed Purchase Exposure are similarly defined.
Similar Maturity Exposure$_i$	Similar Maturity Exposure ranges between zero and one and measures the extent to which the security in question is within the interquartile range of the maturity of the funds holding that security. Weights are determined based on the market value of the security held in each fund's portfolio.
Δ Bond	Measures the quarterly percentage change in mutual fund aggregate holdings to a CUSIP.
Maturity	Provides the maturity of the security in years. Securities with a maturity greater than 50 years are assigned missing values.
Ln (# of funds holding)	Measures the logarithm of the number of funds holding the security in question in the given quarter.
Mean Issuer Δ Holdings	Measures the average quarterly percentage change in mutual fund aggregate holdings to all the CUSIPs of the security's issuer.

References

Albertazzi, U., Becker, B., Boucinha, M., 2016. Portfolio rebalancing and the transmission of large-scale asset programs: evidence from the euro area. ECB Working Paper.

Andrade, P., Breckenfelder, J., De Fiore, F., Karadi, P., Tristani, O., 2016. The reanchoring channel of QE.

Bauer, M., Rudebusch, G., 2014. The signaling channel for Federal Reserve bond purchases. *International Journal of Central Banking* 10, 233–289.

Bean, C., 2011. Lessons on unconventional monetary policy from the United Kingdom. Speech to the US Monetary Policy Forum, New York, 25 February.

Ben-Rephael, A., 2017. Flight-to-liquidity, market uncertainty, and the actions of mutual fund investors. *Journal of Financial Intermediation* 31, 30-44.

Bohn, H., Tesar, L.L., 1996. US equity investment in foreign markets: portfolio rebalancing or return chasing? *American Economic Review* 86, 77–81.

Carpenter, S., Demiralp, S., Ihrig, J., Klee, E., 2013. Analyzing Federal Reserve asset purchases: from whom does the Fed buy? Finance and Economics Discussion Series Working paper.

Chakraborty, I., Goldstein, I., MacKinlay, A., 2016. Monetary stimulus and bank lending.

Chang, X., Dasgupta, S., Wong, G., 2010. Internal cash flows, firm valuation, and the simultaneity of corporate policies. Federal Reserve Board Finance and Economics Discussion Series 2013-32.

Chernenko, S., Sunderam, A., 2015. Liquidity transformation in asset management: evidence from the cash holdings of mutual funds. Ohio State University Working Paper.

Christensen, J., Krogstrup, S., 2016a. A portfolio model of quantitative easing. Peterson Institute for International Economics Working paper No. 16-7.

Christensen, J., Krogstrup, S., 2016b. Transmission of quantitative easing: the role of central bank reserves. Federal Reserve Bank of San Francisco Working Paper 2013-26.

Coval, J., Stafford, E., 2007. Asset fire sales (and purchases) in equity markets. *Journal of Financial Economics* 86, 479–512.

Cremers, K.M., Petajisto, A., 2009. How active is your fund manager? A new measure that predicts performance. *The Review of Financial Studies*, 22 (9), 3329-3365.

Daetz, S.L., Subrahmanyam, M.G., Tang, D.Y., Wang, S.Q., 2016. Did ECB liquidity injections help the real economy in Europe? The Impact of Unconventional Monetary Interventions on Corporate Policies.

D'Amico, S., King, T.B., 2013. The flow and stock effects of large-scale Treasury purchases: evidence on the importance of local supply. *Journal of Financial Economics* 108, 424–448.

Del Negro, M., Eggertsson, G., Ferrero, A., Kiyotaki, N., 2017. The great escape? A quantitative evaluation of the Fed's liquidity facilities. *The American Economic Review*, 107 (3), 824-857.

Diez de los Rios, A., Shamloo, M., 2017. Quantitative easing and long-term yields in small open economies. Bank of Canada Working Paper 2017-26.

Dubofsky, D.A., 2010. Mutual fund portfolio trading and investor flow. *Journal of Banking & Finance*, 34 (4), 802-812.

Edmans, A., Goldstein, I., Jiang, W., 2012. The real effects of financial markets: The impact of prices on takeovers. *The Journal of Finance*, 67 (3),.933-971.

Froot, K.A., Scharfstein, D.S., Stein, J.C., 1992. Herd on the street: informational inefficiencies in a market with short-term speculation, *Journal of Finance* 47, 1461–1484.

Gagnon, J., Raskin, M., Remache, J., Sack, B., 2011. Large-scale asset purchases by the Federal Reserve: did they work? *International Journal of Central Banking* 7, 3–43.

Gertler, M., Karadi, P., 2011. A model of unconventional monetary policy. *Journal of Monetary Economics*, 58 (1), 17-34.

Glick, R., Leduc, S., 2011. Central bank announcements of asset purchases and the impact on global financial and commodity markets. Federal Reserve Bank of San Francisco Working Paper 2011-30.

He, Z., Krishnamurthy, A., 2013. Intermediary asset pricing. *The American Economic Review*, 103 (2), 732-770.

Jotikasthira, C., Lundblad, C., Ramadorai, T., 2012. Asset fire sales and purchases and the international transmission of funding shocks. *Journal of Finance* 67, 2015–2050.

Joyce, M.A.S., Liu, Z., Tonks, I., 2014. Institutional investor portfolio allocation, quantitative easing and the global financial crisis. Bank of England Working Paper No. 510, September.

Kandrac, J., Schlusche, B., 2016. Quantitative easing and bank risk taking: evidence from bank lending. Board of Governors of the Federal Reserve System Working Paper.

Koijen, R.S., Koulischer, F., Nguyen, B., Yogo, M., 2016. Quantitative easing in the euro area: the dynamics of risk exposures and the impact on asset prices. Banque de France Working Paper No. 601.

Koijen, R.S., Koulischer, F., Nguyen, B., Yogo, M., 2017. Euro-area quantitative easing and portfolio rebalancing. *American Economic Review Papers and Proceedings* 107 (5), 621–627.

Krishnamurthy, A., Vissing-Jorgensen, A., 2011. The effects of quantitative easing on interest rates: channels and implications for policy. Brookings Papers on Economic Activity, 215–265.

Krishnamurthy, A., Vissing-Jorgensen, A., 2012. The aggregate demand for Treasury debt. *Journal of Political Economy* 120, 233–267.

Manconi, A., Massa, M., Yasuda, A., 2012. The role of institutional investors in propagating the crisis of 2007-2008. *Journal of Financial Economics* 104 (3), 491–518.

Neely, C.J., 2015. Unconventional monetary policy had large international effects. *Journal of Banking & Finance*, 52, 101-111.

Praet, P., 2015. The transmission of recent non-standard measures. Speech at the Joint BoE, ECB, CEPR and CFM Conference on Credit Dynamics and the Macroeconomy, London, 11 December.

Vayanos, D., Vila, J.-L., 2009. A preferred-habitat model of the term structure of interest rates. NBER Working Paper 15487.

Yellen, J., 2011. The Federal Reserve's asset purchase program. Speech to the Brimmer Policy Forum, Allied Social Science Associations Annual Meeting, Denver, Colorado, 8 January.

Zeng, Y., 2016. A dynamic theory of mutual fund runs and liquidity management. Harvard University Working Paper.

Table 1
Summary Statistics
This table reports summary statistics for the entire sample (pooled observations). Variable definitions are provided in Appendix A.

Panel A: Fund-level Data

	N	Average Fund Size ($ B)	% in Corporate Bonds	% in Agencies	% in Government	% in International	% in Other
Pure Corporate	192	1.14	0.73	.025	.015	.16	.08
Pure Government	170	1.43	.059	.45	.32	.05	.12
Pure International	65	0.29	.045	.003	.03	.90	.03
Pure Other	9	.51	.24	.006	.001	.07	.68
Mixed	460	2.0	.27	.19	.12	.15	.27
Total	896	1.58	.28	.20	.13	.16	.23

Panel B: Security-level Data

	N	% in SOMA	# of Funds Holding CUSIP	Aggregate Position Size ($M)	Flow Exposure	SOMA Exposure	Maturity (Years)	Yield	Spread	HY %
ABS	13,077	0	2.7	9.4	-.001	.15	15.6	.052	.022	.20
Agency	199,500	.076	1.3	4.5	-.009	.23	18.4	.066	.031	.25
Cash	1,099	0	1.0	33.1	.040	.18	2. 4	.037	.024	.16
Corporate Bonds	21,633	0	11.3	41.6	.009	.13	7.5	.061	.036	.35
Government Bonds	1,360	.42	14.0	545.1	.008	.30	5.1	.018	.000	.01
International Bonds	23,267	0	4. 4	21.1	.029	.09	8.1	.056	.035	.29
Municipal Bonds	48,456	0	.5	1.6	-.005	.06	12.2	.041	.014	.08
Non-Agency MBS	17,348	0	2.34	7.8	.008	.15	24.8	.074	.039	.28
Other	2,426	0	2.4	27.7	.010	.06	13.2	.057	.029	.28
Total	328,166	.048	2.2	10.6	-.003	.20	16.1	.062	.030	.24

Table 2

Fund Allocation Changes by Quintile of Exposure to Quantitative Easing

We classify funds based on their exposure to QE purchases. Each quarter, we measure the proportion of the fund's market value that is invested in securities that the Federal Reserve is purchasing. We then divide those funds that have some exposure to QE purchases into quintiles, with funds in the first quintile having the lowest exposure and funds in the fifth quintile having the highest exposure. We measure this allocation change as the dollar change in the fund allocation, as a percentage of the end of the prior quarter's fund assets, less the fund allocation change that could be expected to occur based on fund flows (i.e., the percentage of fund flows multiplied by the percentage of the fund's assets invested in the asset class in the prior quarter).

Panel A: All Funds

Quintile	% Portfolio in QE Securities	% Portfolio in SOMA Securities	Fund AUM ($B)	Fund Flows	QE Gov't Allocation Δ	Non-QE Gov't Allocation Δ	Corporate Allocation Δ	Int'l Allocation Δ	Cash Allocation Δ
1	0.005	0.150	3.83	0.021	0.001	0.001	-0.001	0.002	-0.000
2	0.020	0.217	3.06	0.022	-0.002	0.003	-0.001	0.002	-0.000
3	0.040	0.281	3.83	0.019	-0.005	0.002	0.002	0.003	-0.001
4	0.072	0.360	4.82	0.021	-0.010	0.006	0.002	0.003	0.000
5	0.154	0.471	3.75	0.013	-0.029	0.023	0.003	0.001	0.000
Overall	0.058	0.295	3.86	0.020	-0.009	0.007	0.001	0.002	0.000

Panel B: Mixed Funds

Quintile	% Portfolio in QE Securities	% Portfolio in SOMA Securities	Fund AUM ($B)	Fund Flows	QE Gov't Allocation Δ	Non-QE Gov't Allocation Δ	Corporate Allocation Δ	Int'l Allocation Δ	Cash Allocation Δ
1	0.006	0.140	4.12	0.021	0.001	0.002	-0.001	0.001	0.000
2	0.020	0.193	3.42	0.027	-0.002	0.005	-0.002	0.002	-0.001
3	0.040	0.245	4.18	0.021	-0.005	0.002	0.002	0.003	-0.001
4	0.073	0.327	5.86	0.025	-0.012	0.006	0.003	0.003	0.000
5	0.131	0.387	5.63	0.027	-0.035	0.026	0.005	0.003	-0.000
Overall	0.050	0.253	4.59	0.024	-0.009	0.007	0.001	0.002	-0.000

Table 2 (continued)

Panel C: Pure Funds

Quintile	% Portfolio in QE Securities	% Portfolio in SOMA Securities	Fund AUM ($B)	Fund Flows	QE Gov't Allocation Δ	Non-QE Gov't Allocation Δ	Corporate Allocation Δ	Int'l Allocation Δ	Cash Allocation Δ
1	0.005	0.184	3.35	0.022	0.001	0.000	-0.001	0.003	-0.001
2	0.019	0.317	2.17	0.011	-0.001	-0.001	0.001	0.001	-0.000
3	0.042	0.402	2.94	0.016	-0.002	0.001	0.002	0.002	-0.001
4	0.072	0.485	2.25	0.013	-0.006	0.006	0.000	0.001	-0.001
5	0.178	0.573	1.71	-0.002	-0.021	0.018	0.001	-0.000	0.001
Overall	0.074	0.404	2.43	0.011	-0.007	0.006	0.001	0.001	-0.000

Table 3

Fixed Effects Regressions of Changes in Abnormal Fund Allocation

The dependent variables in these fixed effect regressions are quarterly changes in the abnormal allocation of individual mutual funds to different asset classes. The regression includes fund and time fixed effects. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

Panel A: Mixed Funds

	Abnormal QE Allocation	Abnormal Non-QE Allocation		Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
		Existing	Newly issued				
%SOMA $_{t-1}$	-0.000	-0.141	0.004	0.074	0.019	0.011	0.032
	(0.02)	(10.99)***	(0.27)	(7.84)***	(3.78)***	(2.57)**	(4.19)***
%QE $_{t-1}$	-0.313	0.135	0.160	0.025	-0.002	-0.010	0.004
	(9.77)***	(3.95)***	(3.80)***	(2.61)**	(0.22)	(1.70)*	(0.30)
Fund flows $_{t-1}$	-0.006	0.040	0.108	-0.085	-0.033	0.030	-0.054
	(2.05)**	(2.91)***	(6.61)***	(9.87)***	(7.73)***	(4.44)***	(7.78)***
Fund return $_{t-1}$	-0.006	-0.122	0.002	0.081	0.011	-0.020	0.055
	(0.23)	(1.55)	(0.03)	(1.43)	(0.35)	(0.89)	(1.07)
R^2	0.41	0.20	0.26	0.16	0.08	0.08	0.11
N	8,233	8,233	8,233	8,233	8,233	8,233	8,233

Panel B: Pure Funds

	Abnormal QE Allocation	Abnormal Non-QE Allocation		Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
		Existing	Newly issued				
%SOMA $_{t-1}$	-0.005	-0.096	0.039	0.023	0.008	0.007	0.023
	(0.64)	(4.34)***	(1.79)*	(1.99)*	(2.53)**	(1.51)	(3.09)***
%QE $_{t-1}$	-0.162	0.111	0.054	0.006	-0.014	0.007	-0.002
	(7.25)***	(3.70)***	(1.41)	(0.89)	(3.84)***	(1.09)	(0.36)
Fund flows $_{t-1}$	-0.006	-0.045	0.080	-0.022	-0.012	0.025	-0.020
	(1.33)	(2.28)**	(4.32)***	(3.31)***	(2.90)***	(4.43)***	(3.44)***
Fund return $_{t-1}$	-0.025	-0.083	0.048	0.042	0.011	-0.016	0.023
	(1.55)	(1.55)	(0.86)	(2.13)**	(0.71)	(1.70)*	(1.20)
R^2	0.25	0.29	0.35	0.08	0.09	0.11	0.07
N	7,964	7,964	7,964	7,964	7,964	7,964	7,964

Table 4

Fixed Effects Regressions of Individual Fund Flows

The dependent variables in these fixed effect regressions are quarterly mutual fund net flows (as a percentage of the previous quarter's assets under management). The regression includes fund (columns 1-4) and time (columns 1-2) fixed effects. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	(1)	(2)	(3)	(4)
Fund flows $_{t-1}$	0.109	0.109	0.129	0.126
	(4.59)***	(4.59)***	(4.95)***	(4.88)***
Fund return $_{t-1}$	0.178	0.176	0.115	0.131
	(0.30)	(5.65)***	(0.82)	(0.89)
Family flows $_{t}$	0.197	0.196	0.302	0.305
	(5.75)***	(5.68)***	(7.44)***	(7.35)***
QE			-0.014	-0.013
			(1.70)*	(1.62)
QE * IG Corporate Fund	0.017	0.016	0.014	0.014
	(1.90)*	(1.77)*	(1.68)	(1.57)
QE * HY Corporate Fund	0.037	0.038	0.034	0.036
	(2.26)**	(2.11)**	(2.11)**	(1.99)*
QE * International Fund	0.020	0.020	0.016	0.015
	(1.72)*	(1.52)	(1.34)	(1.18)
QE * Other Fund	0.052	0.052	0.050	0.049
	(1.82)*	(1.81)*	(1.75)*	(1.72)*
Post-2010		0.008		0.007
		(0.60)		(0.62)
Post-2010 * IG Corporate Fund		-0.003		0.001
		(0.14)		(0.03)
Post-2010 * HY Corporate Fund		0.006		0.011
		(0.31)		(0.62)
Post-2010 * International Fund		0.011		0.004
		(1.46)		(0.41)
Post-2010 * Other Fund				-0.013
				(1.51)
R^2	0.24	0.24	0.21	0.21
N	6,956	6,956	6,956	6,956

Table 5

Fixed Effects Regressions of Individual Fund Flows

The dependent variables in these fixed effect regressions are quarterly mutual fund net flows (as a percentage of the previous quarter's assets under management). The regression includes fund and time fixed effects. Standard errors are clustered at the fund level. Absolute values of t statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	All Pure Funds	Pure Government Funds
%SOMA $_{t-1}$	-0.004	0.006
	(0.20)	(0.33)
%QE $_{t-1}$	-0.128	-0.072
	(2.65)**	(1.96)*
Fund flows $_{t-1}$	0.112	0.073
	(4.71)***	(2.24)**
Fund return $_{t-1}$	0.229	0.419
	(1.18)	(1.76)*
R^2	0.23	0.23
N	7,422	3,568

Table 6

Fixed Effects Regressions of Aggregate Fund Flows (by Asset Class)

The dependent variables in these fixed effect regressions are aggregate quarterly mutual fund net flows (as a percentage of the previous quarter's assets under management), which are decomposed into Internal Net Exchanges (i.e., within-family flows) and External Net Flows (i.e., outside family flows). Standard errors are clustered at the asset class level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	Total Net Flows $_{s,t}$	Internal Net Exchanges $_{s,t}$	External Net Flows $_{s,t}$
Total Net Flows $_{s,t-1}$	0.618		
	(23.06)***		
Internal Net Exchanges $_{s,t-1}$		0.428	
		(13.95)***	
External Net Flows $_{s,t-1}$			0.651
			(25.03)***
QE $_t$	-0.002	-0.001	-0.001
	(1.04)	(2.22)**	(0.49)
Investment Grade Bond $_s$	0.001	0.000	0.001
	(1.21)	(0.12)	(1.42)
QE $_t$ * Investment Grade Bond $_s$	0.001	0.001	0.001
	(0.63)	(1.23)	(0.33)
High Yield Bond $_s$	-0.001	-0.001	-0.000
	(0.92)	(1.91)*	(0.53)
QE $_t$ * High Yield Bond $_s$	0.005	0.002	0.003
	(2.00)**	(2.76)***	(1.51)
World Bond $_s$	0.001	-0.000	0.001
	(0.86)	(0.25)	(1.08)
QE $_t$ * World Bond $_s$	0.006	0.002	0.005
	(2.71)***	(2.41)**	(2.46)**
Constant	0.001	0.000	0.001
	(1.15)	(1.50)	(0.86)
R^2	0.44	0.21	0.48
N	852	852	852

Table 7

Fixed Effects Regressions of Changes in Abnormal Fund Allocation by Agency vs. Treasury Securities in Mixed Funds

The dependent variables in these fixed effect regressions are quarterly changes in the abnormal allocation of individual mutual funds to different asset classes. The regression includes fund and time fixed effects. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal QE Agency Allocation	Abnormal QE Treasury Allocation	Abnormal Non-QE Agency Allocation	Abnormal Non-QE Treasury Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
%SOMA Agency $_{t-1}$	0.061	-0.009	-0.012	0.009	-0.101	0.062	-0.020	0.009
	(2.75)***	(0.73)	(0.51)	(1.25)	(2.94)***	(1.48)	(1.31)	(0.51)
%QE Agency $_{t-1}$	0.012	0.009	-0.240	-0.009	0.118	0.119	0.004	-0.013
	(0.64)	(0.91)	(10.16)***	(1.12)	(1.95)*	(2.62)**	(0.30)	(0.45)
%SOMA Treasury $_{t-1}$	0.048	0.015	0.011	0.003	0.122	-0.239	0.028	0.013
	(4.07)***	(1.53)	(2.69)**	(0.45)	(4.92)***	(7.45)***	(2.90)***	(1.06)
%QE Treasury $_{t-1}$	0.035	-0.036	0.022	-0.428	0.032	0.431	-0.024	-0.031
	(2.13)**	(1.85)*	(1.50)	(7.48)***	(0.67)	(6.66)***	(1.97)*	(1.76)*
%SOMA Agency $_{t-2}$	0.002	0.019	-0.015	0.003	-0.019	-0.033	0.018	0.025
	(0.11)	(1.40)	(0.77)	(0.22)	(0.42)	(0.70)	(1.44)	(1.07)
%QE Agency $_{t-2}$	0.014	0.012	0.014	-0.003	-0.024	-0.063	-0.010	0.060
	(0.67)	(1.26)	(0.72)	(0.39)	(0.47)	(1.21)	(0.70)	(2.26)**
%SOMA Treasury $_{t-2}$	0.039	0.009	-0.011	-0.001	-0.042	-0.000	-0.017	0.024
	(3.50)***	(1.01)	(2.41)**	(0.26)	(1.89)*	(0.01)	(1.86)*	(2.55)**
%QE Treasury $_{t-2}$	0.008	0.036	-0.006	-0.010	-0.068	-0.027	0.039	0.027
	(0.55)	(2.36)**	(0.28)	(0.48)	(1.39)	(0.68)	(2.52)**	(1.10)
Fund flows $_{t-1}$	-0.085	-0.033	-0.002	-0.004	0.065	0.083	0.030	-0.054
	(9.89)***	(7.70)***	(1.07)	(2.46)**	(4.48)***	(9.89)***	(4.47)***	(7.83)***
Fund return $_{t-1}$	0.085	0.016	-0.003	-0.012	-0.163	0.029	-0.015	0.062
	(1.51)	(0.55)	(0.11)	(0.45)	(2.52)**	(0.55)	(0.64)	(1.27)
R^2	0.16	0.08	0.33	0.49	0.12	0.20	0.08	0.12
N	8,233	8,233	8,233	8,233	8,233	8,233	8,233	8,233

Table 8

Fixed Effect Regressions Describing Changes in Fund Holdings of SOMA Securities

The dependent variables in these fixed effect regressions are the percentage quarterly changes in mutual fund holdings of the security, and the percentage change in the number of individual funds that hold the security. The first three columns examine changes in Agency securities at a CUSIP level, and the three rightmost columns examine changes in government securities at a CUSIP level. All variables are described in Appendix A. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	Agency Securities		**Government Securities**	
	%Δ Fund Holdings	**%Δ # Funds**	**%Δ Fund Holdings**	**%Δ # Funds**
$FIFA_t$	0.683	0.489	0.627	0.096
	(98.36)***	(7.58)***	(9.23)***	(0.57)
SOMA Indicator * QE_t	-0.222	-0.208	-0.106	-0.068
	(44.47)***	(6.44)***	(6.06)***	(4.98)***
Constant	-0.283	-0.340	-0.236	-0.156
	(64.77)***	(8.68)***	(11.80)***	(6.07)***
R^2	0.24	0.00	0.07	0.03
N	104,177	107,205	7,723	8,071

Table 9

Fixed Effects Regressions of Changes in Abnormal Fund Allocation – Robustness to Threshold in Mixed Funds

The dependent variables in these fixed effect regressions are quarterly changes in the allocation of individual mutual funds to specific asset classes, beyond the allocations that would be expected based on their flows. In this table, a Federal Reserve Treasury purchase is classified as a QE purchase if the Federal Reserve purchases at least 1% of the outstanding par value of a given bond in a given quarter (as opposed to a 5% threshold in our main analysis). The regression includes fund and time fixed effects. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	Abnormal Corporate Allocation	Abnormal International Allocation	Abnormal QE Allocation	Abnormal Non-QE Allocation	Abnormal Cash Allocation	Abnormal Other Allocation
%SOMA $_{t-1}$	0.076	0.021	-0.003	-0.138	0.011	0.034
	(7.86)***	(4.29)***	(0.36)	(10.60)***	(2.28)**	(4.22)***
%QE $_{t-1}$	0.017	-0.005	-0.279	0.276	-0.012	0.002
	(1.83)*	(0.67)	(11.96)***	(8.40)***	(1.73)*	(0.21)
Fund flows $_{t-1}$	-0.083	-0.032	-0.006	0.150	0.027	-0.056
	(9.58)***	(7.47)***	(1.61)	(10.26)***	(4.56)***	(7.88)***
Fund return $_{t-1}$	0.079	0.003	-0.023	-0.090	-0.013	0.044
	(1.36)	(0.10)	(0.85)	(0.78)	(0.56)	(0.83)
R^2	0.16	0.07	0.39	0.21	0.05	0.11
N	7,781	7,781	7,781	7,781	7,781	7,781

Table 10

Fixed Effects Regressions of Changes in Abnormal Fund Corporate Allocation – Mixed Fund Robustness

The dependent variables in these fixed effect regressions are the quarterly changes in the allocation of individual mutual funds to corporate bonds, beyond the allocations that would be expected based on their flows. Column (1) presents the baseline results and columns (2) – (4) present different subsets of funds. Column (2) eliminates any funds classified as index funds by Morningstar. Column (3) eliminates any funds with a Cremers and Petajisto (2009) Active Share below 0.6, while column (4) eliminates those with an Active Share below 0.9. The regression includes fund and time fixed effects. Standard errors are clustered at the fund level. Absolute values of *t* statistics are in parentheses. * indicates statistical significance at the 10% threshold; ** indicates statistical significance at the 5% threshold; and *** indicates statistical significance at the 1% threshold.

	Abnormal Corporate Allocation	Abnormal Corporate Allocation (Non-index)	Abnormal Corporate Allocation (Active Share > 0.6)	Abnormal Corporate Allocation (Active Share > 0.9)
%SOMA $_{t-1}$	0.049	0.049	0.049	0.072
	(4.26)***	(4.17)***	(4.20)***	(5.21)***
%QE $_{t-1}$	0.021	0.022	0.022	0.021
	(1.72)*	(1.78)*	(1.77)*	(0.83)
%SOMA $_{t-2}$	0.032	0.034	0.034	0.028
	(2.98)***	(3.10)***	(3.09)***	(2.47)**
%QE $_{t-2}$	0.005	0.004	0.004	-0.007
	(0.31)	(0.22)	(0.24)	(0.30)
Fund flows $_{t-1}$	-0.085	-0.086	-0.086	-0.076
	(9.82)***	(9.78)***	(9.77)***	(8.96)***
Fund return $_{t-1}$	0.083	0.096	0.097	0.099
	(1.47)	(1.63)	(1.66)	(1.77)*
R^2	0.16	0.16	0.16	0.16
N	8,233	7,873	7,858	6,405

Figure 1

This chart displays the number of individual Treasury CUSIPs the Federal Reserve purchased each quarter as a percentage of the number of Treasury CUSIPs held by mutual funds that quarter. Similarly, it also displays the number of individual Agency CUSIPs the Federal Reserve purchased each quarter as a percentage of the number of Agency CUSIPs held by mutual funds that quarter.

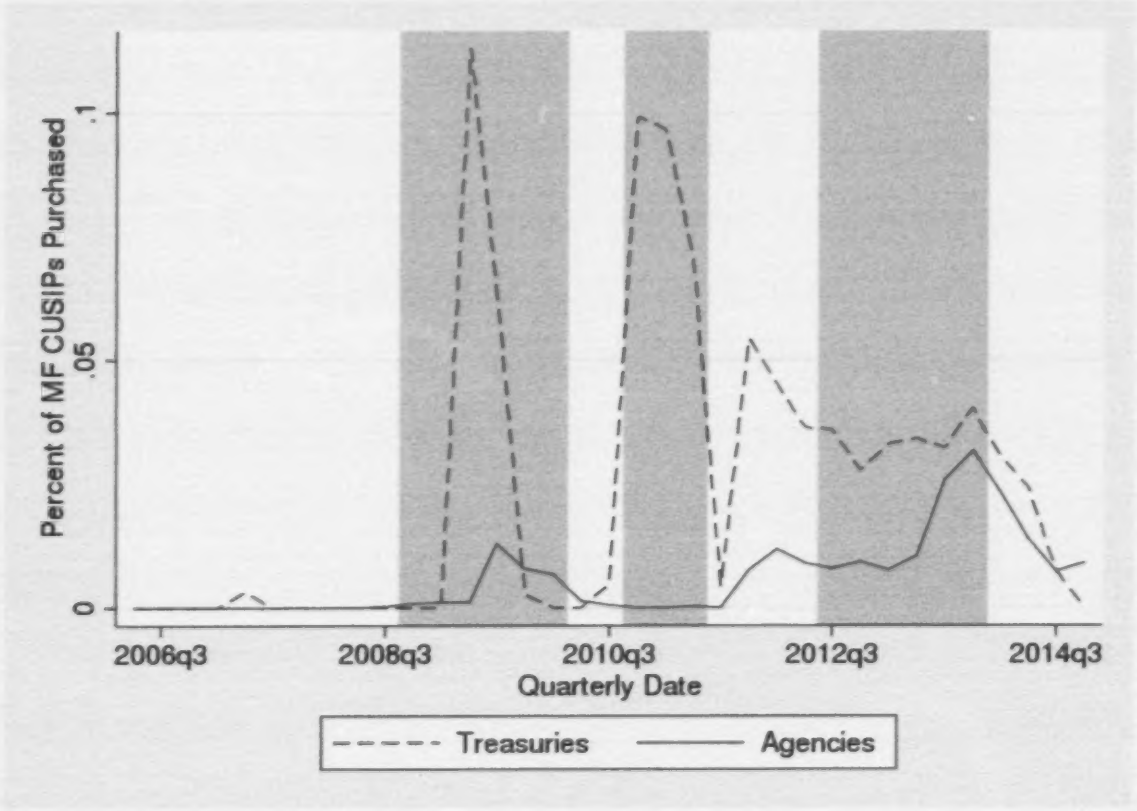


Figure 2

This chart displays changes in fund allocation based on their exposure to quantitative easing. We classify funds based on their exposure to QE purchases. Each quarter, we measure the proportion of the fund's market value that is invested in securities that the Federal Reserve is purchasing. We then divide those funds that have some exposure to QE purchases into quintiles, with funds in the first quintile having the lowest exposure and funds in the fifth quintile having the highest exposure. We measure this allocation change as the dollar change in the fund allocation, as a percentage of the end of the prior quarter's fund assets, less the fund allocation change that could be expected to occur based on fund flows (i.e., the percentage fund flows multiplied by the percentage of the fund's assets invested in the asset class in the prior quarter).

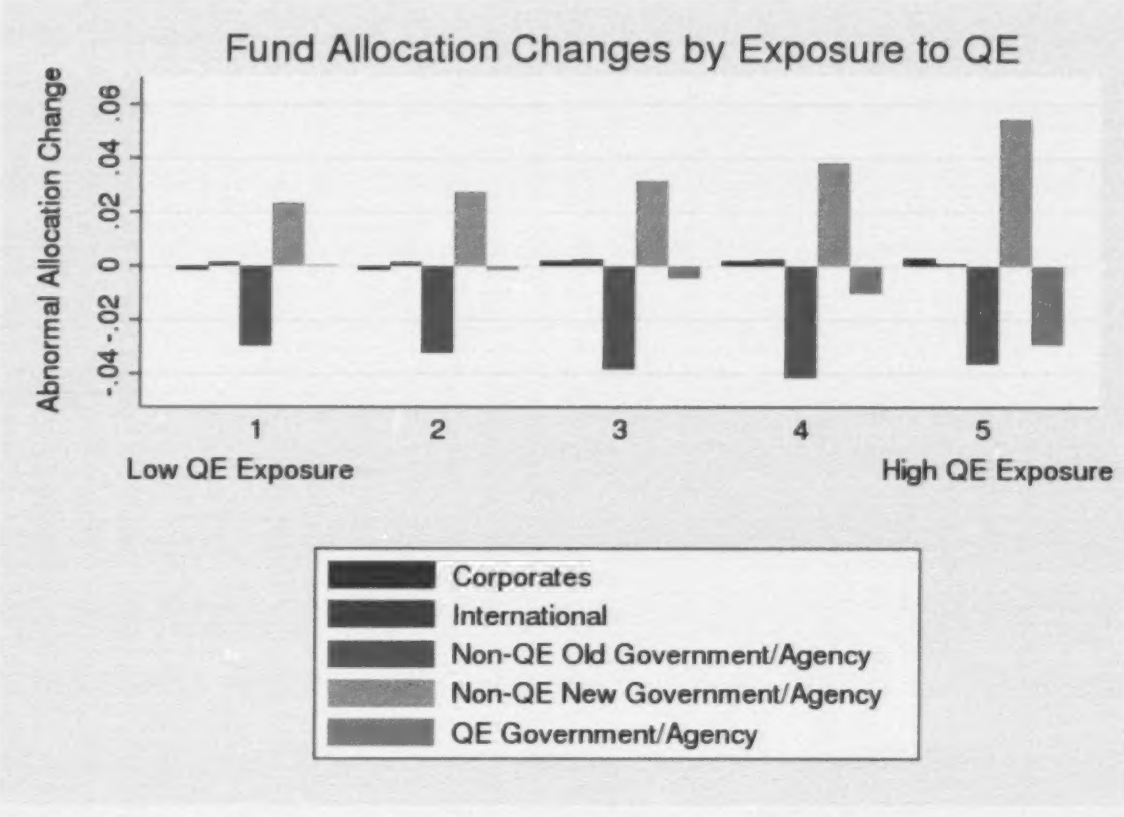
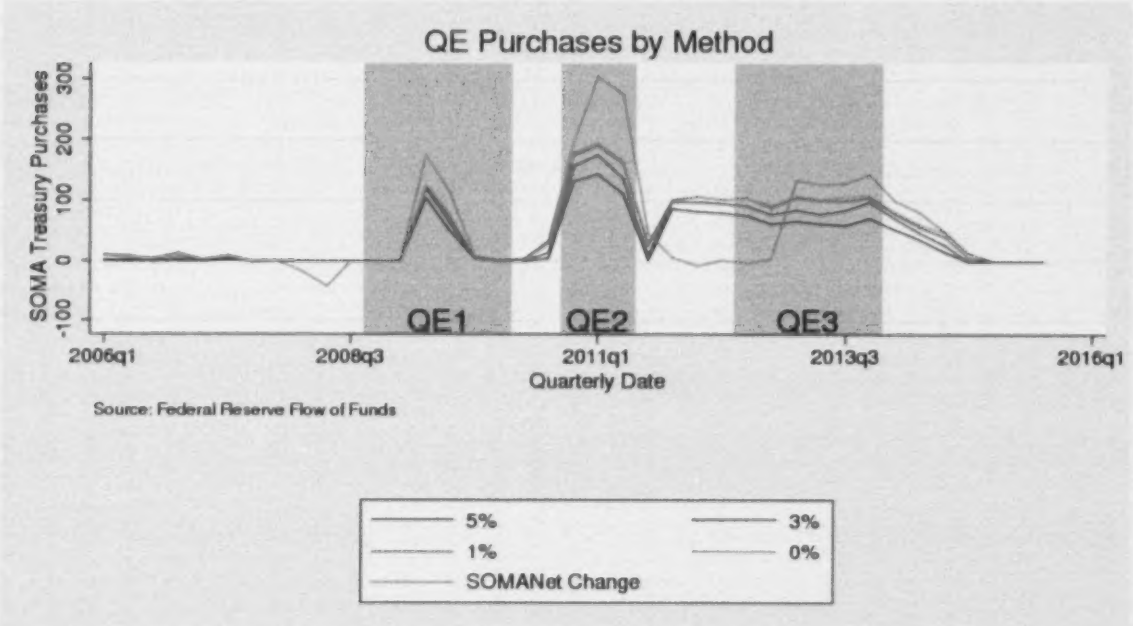


Figure 3

This chart displays the aggregate amount of QE purchases based on the threshold used to classify a change in the SOMA portfolio as a purchase. These thresholds range from 0% of the outstanding stock of a given bond to 5% of the outstanding stock of the bond. For comparison purposes, the figure also displays the quarterly net change in the SOMA portfolio.